Managing Coal Washery Waste and Effluent
A Case Study

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1. INTRODUCTION

JCOAL, a non-profit foundation having Japanese coal-related companies as its members, is performing various activities, based on the coal energy policy of the Japanese government. Particular emphasis is placed on called upstream coal technology such as exploration technology, coal mine safety and production technology, coal cleaning technology, and technology to reduce the burden on the environmental issue which accompanies coal production.

The organization is now conducting various activities in Vietnam such as a geological survey of the Red River, joint research on base rock driving technology, longwall mining technology, rock bolting technology, and other technologies in a coal mine in the Cam Pha area, as well as the human resources development project, and the introduction of coal cleaning technology to reduce the environmental load related to the theme of this paper, and various investigations of coal preparation plants with the aim of realization of the project.

Based on the investigation report, this case study deals with the coal industry in Vietnam, conditions of coal preparation, the role to be played by coal preparation plants to reduce the environmental load, importance of coal quality control, and the environmental problems and countermeasures of coal preparation plants themselves.

2. SITUATION OF THE COAL INDUSTRY

2.1 State of the Coal Industry

Since the reforms based on the Doi Moi Line began to bring forth good results around 1989, the Vietnamese economy has changed and economic growth of 8 – 9% has been attained in recent years. However, economic growth slowed in 1997 because of the impact of the economic crisis in Asia as well as domestic structural factors. Since Vietnam is now facing an export slump and a sudden decrease in foreign funds as a result, intensification of its economic competitiveness is a critical issue to overcome considering its current GDP of US$23.5 billion (based on IMF Material for '96), GNP per person of US$320 (based on World Bank Material for '97), an economic growth rate of 5.8% for '98 and a price increase ratio of 9.2% as announced by the Government.

As for the role of the coal industry amidst this rapid-paced economic development, demand from the power-generation sector and the cement industry has been steeply increasing for domestic use, leading to the growing consumption of coal. The demand for coal from power plants and cement plants over the five-year period which started in 1998 is expected to grow more than 2 fold and 4 fold, respectively. Furthermore, there is a tendency to get tough about coal quality control and environmental problems. Some coal has been shipped out without being washed. But, even buyers of such coal have begun demanding the washed coal. Also as for on

the export coal, the stepping-up of coal-cleaning capacity has become a challenging matter requiring urgent attention.

2.2 Supply and Demand

As for the coal demand and supply outlook from 1998 through 2010, a base scenario and a high demand scenario are shown in Table 2.1.

Table 2.1 EXPECTED DEMAND FOR COAL - BASE & HIGH SCENARIO

Unit:1,000t

Consumer	History				Projections		
	1996	1997	1998	1999	2000	2005	2010
Export	**3,666**	**3,448**	**2,900**	**3,400**	**3,200**	**1,300**	**500**
Domestic	**5,985**	**7,848**	**7,821**	**7,646**	**8,534**	**12,425**	**17,500**
Power	*1,570*	*2,783*	*2,277*	*2,300*	*2,800*	*4,500*	*6,800*
Fertiliser	*420*	*352*	*201*	*440*	*464*	*740*	*830*
Paper	*135*	*170*	*172*	*160*	*160*	*180*	*200*
Cement	*610*	*680*	*559*	*1,900*	*2,100*	*3,500*	*5,000*
Construction material & household	*3,250*	*3,863*	*4,612*	*2,846*	*3,010*	*3,505*	*4,670*
Base Scenario Total	**9,651**	**11,296**	**10,721**	**11,046**	**11,734**	**13,725**	**18,000**
High Scenario Total					**12,500**	**15,000**	**19,500**

1) Electric Power Industry

There are currently three thermal power plants that use coal as fuel. The construction of the No.2 unit (300MW x 2 sets) at Pha Lai Power Plant is scheduled to be completed in 2001. Subsequent projects include the construction of Quang Ninh Power Plant (300MW) and the addition of the No.2 unit (300MW) at Uong Bi Power Plant. On the other hand, IPP (Independent Power Producer) projects such as the 100MW power plant at Na Duong, drawn up by coal mining companies, have also been approved by the Government. These projects are being pushed forward with the objective of lowering the percentage of hydroelectric power, and thereby alleviating the problem of unstable power supply due to shortages of rainfall caused by the unseasonable weather in recent years. Table 2.2 shows the percentages of individual energy sources for power generation in 1995 and 1999.

Table 2.2 ENERGY CONTRIBUTIONS FOR POWER GENERATION

	Production (GWh)	Hydro (%)	LNG (%)	Coal (%)	Oil & Diesel (%)
1995	14,637	72.4	6.9	13.8	6.9
1999	23,730	58.7	17.6	12.2	11.5

2) Cement Industry

Since, at present, the production of cement cannot catch up with demand, the construction of additional production plants and the upgrading of production systems are being contemplated. With a plan to produce 40 million tons in 2010 (vs. 7 million tons in 1996), the amount of coal

required for cement production accounts for approximately 9% of the total quantity of cement production. Half of this amount will be requested to be washed coal.

3) Other Industries

Taking a look at other industries, coal is being used for fuel in the manufacture of bricks, lime, tiles, as building material, and fertilizer. Furthermore, for households and for use as cooking fuel, cubic and cylindrical briquettes of compressed fine coal are being used and most of their material is unwashed coal or sunny dried sediment from a settling pond at the preparation plant.

4) Exports

In 1997, 3.5 million tons of coal were exported, half of which was destined for Japan. Since Vietnamese coal is anthracite (high fixed Carbon, low volatile matter coal), there is a limit to its use for boilers mainly fueled by bituminous coal. However, high-calorie lumpy coal is internationally competitive and regarded as an attractive product from the viewpoint of acquisition of foreign currencies. On the other hand, as demand keeps on growing in the future, consumption is predicted to outpace supply and, under pressure from resultant shortages, a gradual reduction in exports is forecast over the long term.

2.3 Production of Coal

Most of Vietnam's coal producing regions are concentrated in the northern part of the economy, scattered along the western coastline of Hanoi. Coal mining methods can be classified as open-cut and underground mining. At present, open-cut mining accounts for 70% of the total coal production. From the year 2005 onward, underground mining is anticipated to increase and account for 50% to 60%. As of 2010, the percentage is predicted to reach 60% to 70%. Judging from Vietnam's coal deposit patterns, it will become necessary to wash raw coal extracted from coalmines for quality control. This, in turn, makes it an absolutely necessity to enhance coal washing capacities in keeping with the economy's growing coal production.

As of 1997, VINACOAL owned four major open cut coal mines, each producing over one million tons per year. These are the Cao Son, Coc Sau, Deo Nai and Ha Tu mines. In addition, there are 15 coal mines, each producing 100,000 to 300,000 tons of raw coal per year, and small-sized open-cut coal mines, each producing less than 100,000 tons, in 10 places. VINACOAL's raw coal production performance is shown in Table 2.3. As can be seen from this table, 80% of the total coal production derives from the Hon Gai and Cam Pha areas near the Ha Long Bay.

Table 2.3 RAW COAL PRODUCTION PRODUCED BY VINACOAL (UNIT:1,000T)

No.	Company	1995	1996	1997
1	Uong Bi	1,438	1,638	2,006
2	Hon Gai	3,171	4,090	4,797
3	Cam Pha	4,085	5,076	5,584
4	Noi dia	631	609	629
	Total	9,369	11,412	13,019

3.THE ACTUAL STATE OF COAL PREPARATION

3.1 Coal Preparation and Screening

In developed countries, all raw coal is washed and the total amount of cleaned coal equals the amount processed by a coal preparation plant. However, in developing countries, coal classification and preparation should be handled separately for fear that processed amounts may be misunderstood.

Since excavated raw coal varies in sizes, it should be classified for their purposes, and this process is called "classification or screening". In this report, the only classified coal is called "unwashed coal" even though some size of screened coal also decreases ash. In case adjustment of ash content (calorific value) is required, the process of coal preparation is essential and the coal prepared with this cleaning process is called "clean coal or washed coal". The process of Vietnamese coal preparation plants includes both classification and preparation of salable coal. Fig. 3.1 is a flow chart of the outlined process.

3.2 Concept of Coal Preparation in Vietnam

The amount of coal prepared in Vietnam accounts for approximately 35% (as of 1997) of the total amount of coal products, and the rest is classified only through screening which includes mechanized screen and simplified screening.

Coal preparation plants currently in operation are as shown in Table 3.2.

3.3 Specifications for Products

Table 3.3 represents a typical example of specifications for major brands of clean coal currently shipped from Cua Ong Coal Preparation Plant.

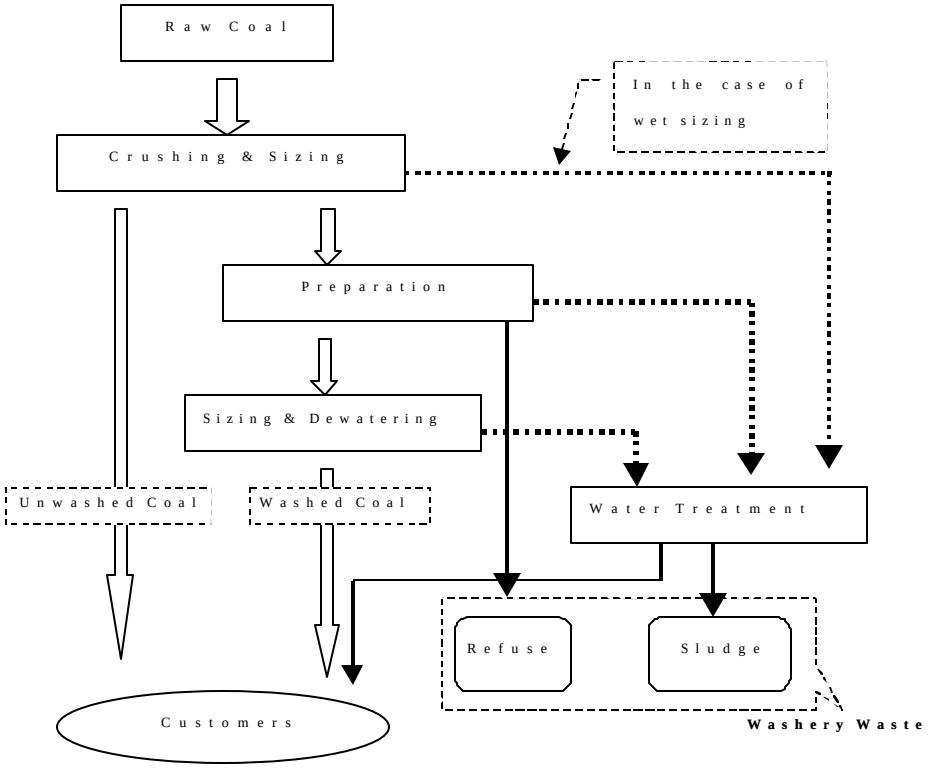

Fig.3.1 FLOW SHEET FOR SALABLE COAL

Table 3.2 EXISTING PREPARATION PLANT IN VIETNAM

Company Name		Process	Capacity (1,000t/y Raw coal)			Remarks
			Actual Capacity		Design Capa.	
			Washing	Sizing		
Cua Ong Coal Preparation Enterprise	No.1	Sizing and Washing	200	300	2,500	1925 established (by French)
	No.2	Sizing and Washing	2,000	500	3,200	1980 operation (by Poland) 1990 rehabilitated (by Australia)
Vang Danh Coal Mine		Sizing and Washing	500		600	1964 established (by Former Soviet U.)
Hong Gai Coal Preparation Plant		Sizing and Washing	1,500		2,000	1996 rehabilitated (by Australia)
Mao Khe Coal Mine		Sizing		1,000		1945 established (by French)
(Subcontractor)		Sizing	(Depend on market)			Hand picking

Table 3.3 MAIN CHARACTERISTICS OF SALABLE COAL

Grade No.	Size (mm)	Moisture (Max.%)	Ash (%) (Dry basis)	Volatile Matter (Dry Basis)	Sulfur (max. %) (Dry Basis)	Calorific Value (kcal/kg) (Dry Basis)	Fixed carbon (%) (Dry basis)	Hardgrove Index	Ash Fusion Temperature		
									Deformation	Hemisphere	Flow
1	35 - 100	6	8 – 12	6 – 8	0.6	7,200	81	29	1,250	1,360	1,450
2	50	4	6 – 8	5 – 7	0.6	8,300 – 8,100	88	30	1,260	1,380	1,450
3	35 - 50	4	3 – 5	5 – 7	0.6	8,300 – 8,000	87	31	1,260	1,380	1,450
4	15 – 35	5	4 – 6	5 – 7	0.6	8,200 – 7,900	86.5	32	1,260	1,380	1,450
5	6 - 18	5	5 – 7	5 – 7	0.6	8,100 – 7,900	86	32	1,260	1,380	1,450
6	0 – 15	8	6 – 8	6 – 8	0.6	8,000 – 7,800	83	35	1,250	1,350	1,450
7	0 – 15	8	8 – 10	6 – 8	0.6	7,800 – 7,600	91	40	1,250	1,350	1,450
8	0 – 15	8	10 – 15	6 – 8	0.6	7,600 – 7,200	77	45	1,250	1,350	1,450
9	0 – 15	8	15 – 22	6 – 8	0.6	7,200 – 6,500	70	46	1,250	1,350	1,450
10	0 – 15	8	22 – 32	6 – 8	0.6	6,500 – 5,600	65	53	1,250	1,350	1,450
11	0 – 15	8	32 – 40	6 – 8	0.6	5,500 – 4,600	62	62	1,250	1,350	1,450

4. ENVIRONMENTAL BENEFITS OF WASHED COAL

The main purpose of coal washing is to produce coal which has the specifications desired by customers as merchandize. The main role of coal washing is the adjustment of coal size, ash content, and moisture content. As a matter of course, it includes the removal of other objects mixed with raw coal such as broken pieces of iron or wood, plastics, belts, etc. Among them, it is the adjustment of ash content that plays the role of reducing the environmental load when coal is utilized. Generally, the ash content of raw coal in Vietnam ranges from 35% to 50%, depending on the production site. The ash content is adjusted to 3% or more through a preparation plant as shown in Table 3.3,

The following environmental load-reducing effect can be enhanced by using coal containing less ash which is produced through satisfactory quality control.

-Decrease in the amount of burned ash to be disposed
-Decrease in sulfur content
-Improvement of combustion efficiency
-Stable operation of boiler
-Decrease in handling costs

In this sense, the coal preparation plants can reduce the costs of environmental protection facilities by lessening the load of dust collectors, flue gas desulfurization facilities, burned ash disposal facilities, etc. on the users' side by decreasing environmental load factors in advance when coal is utilized. Figure 4.1 shows, as a reference, the costs incurred when coal is used.

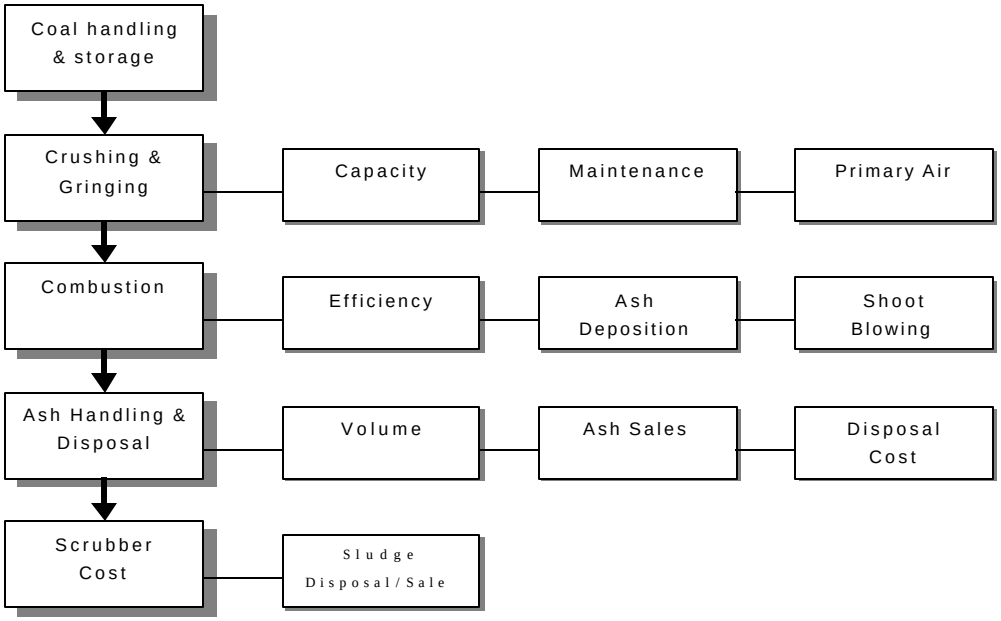

Figure4.1 Some Utility Cost Impacted by Coal Quality

This section describes in detail the effect of decreasing sulfur content through coal washing. Generally speaking, there is no problem because the Vietnamese coal currently used does not contain much sulfur. However, if more coal is required in the future, coal containing a high rate of sulfur also will be mined to make an effective utilization of coal resources. At present, the

construction of a new thermal power plant with a circulating fluidized bed (CFB) using coal of a low heat value (3,500 kcal/kg) and a high rate of sulfur (6.5%) in Na Doung is scheduled. This method will be applied with the use of limestone for desulfurization to protect the environmental from pollution. This is an example of using unwashed coal containing a high rate of sulfur in such a manner that user side take environmental conservation measures.

The Coal Age, an American magazine, carried a story on how much sulfur coal washing can remove. In the case of The United States, SO_2 credits are currently bought and sold. The idea of coal washing is grasped as described below.

”Coal washing provides an alternative to purchasing SO_2 credits, and even though it may not be possible to wash a given coal to level of compliance coal, it may be worthwhile to wash that coal to reduce the number of credits required to offset SO_2 emissions”.

Figure 4.2 is the result of a sink-and-float test of raw coal used as an example. The relative density increases toward the right along the abscissas. Note the sulfur content at each relative density. The figure shows that the higher the relative density is, in other words, the higher the ash content is, the higher the sulfur content is.

Figure 4.3 shows the recovery of coal washed with each ash content, in percentage by weight.

Figure 4.4 shows average sulfur content with an average ash content.

These figures reveal that this raw coal contains 26% ash and 4.2% sulfur and, for example of effect of washed coal, when the coal washing is conducted so that the ash content is 15%, the sulfur content will decrease to 2.5% and the theoretical recovery percentage will be 80%. It is natural that ash content decreases, resulting in an increase in calorific value.

Therefore, an analysis of the properties of the specific raw coal and an economic evaluation, including coal washing and utilization, may be required in order to judge whether it is better if coal of a high sulfur content is burned as it is or burned after the ash content and sulfur content are reduced by coal washing.

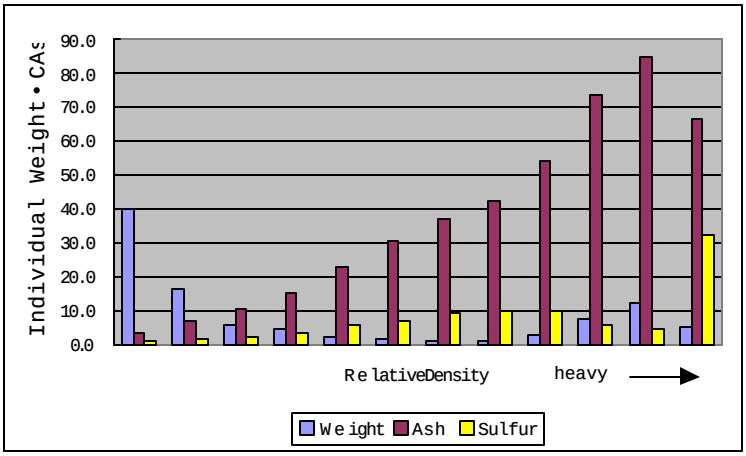

Figure 4.2. Correlation of Ash Content vs. Individual Weight at each relative Density

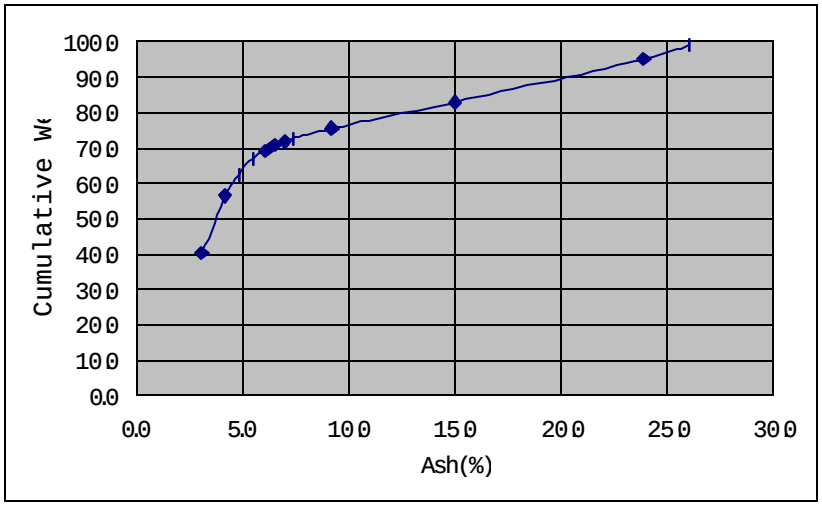

Figure 4.3. Correlation of Cumulative Ash Content vs. Cumulative Weight

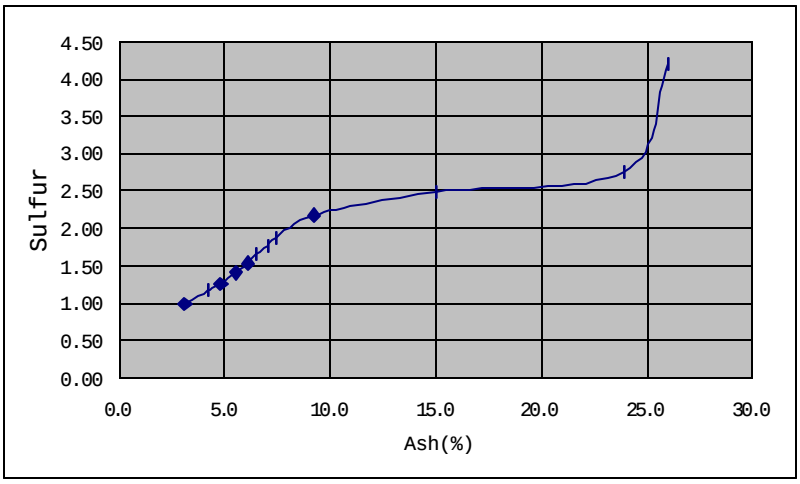

Figure 4.4 Correlation of Cumulative Ash Content vs. Cumulative Sulfur

5. ENVIRONMENTAL ISSUES IN COAL PREPARATION PLANTS

The following environmental issues will occur in coal preparation plants.

-Wastewater
-Washery waste
-Noise and dust

Although the amount of water used for coal washing depends on the method, coal preparation plants are compelled to use a large quantity of water. As a result, wastewater polluted by the fine particle of coal and other materials is generated. Unlike metal mines, wastewater from coal preparation plants generally contains fewer toxic substances such as heavy metals. Suspended solid and COD cause a major problem. Wastewater may, sometimes, contain a little amount of heavy metal due to supplied water quality for washing.

Washery waste refers to coarse-grained low-grade coal and rocks generated from coal washing and the coal sludge with high rate of moisture left after wastewater treatment. Unless this washery waste is converted into value-added material, any country would want to minimize its treatment costs. As a result, environmental problems may arise in some cases.

Noise and dust are generated in plants, raw coal yards, and clean coal yards. They are mainly generated in places near dry-type vibrating screens, crushers and belt discharging locations. They tend to be a big issue because Vietnamese coal is soft and easily pulverized.

6. ENVIRONMENTAL MEASURES IN A COAL PREPARATION PLANT

Basic environmental measures in a coal preparation plant are considered as follows;

Sustained effort to Increase a coal yield
Treating waste water and circulating usage of washery water
Effective utilization of Washery waste
Noise and dust measures and equipment

6.1 Sustained Effort to Increase a Coal Yield

The common measure in both waste water treatment and washery waste treatment is that collectable coal should be collected while always aiming to decrease salable coal in waste material as much as possible. As a result, increasing coal yield as well as lowering of the environmental load will increase profit, while lowering the cost of waste treatment.

To increase the coal yield, management of the coal preparation process, especially of the washing machine and screen, is important. In addition, it is also important to make everyone from the managers to the operators in the plant highly aware of coal quality control. In washing machines, it is important whether the equipment, with which the operator can monitor how the washers select coal at present, functions or not. Whether functioning depends on the skill of the operator or some level of monitoring equipment may vary at each plant. Ideally, the washers should carry out quality control automatically regardless of their level of ability. However, in

developing countries, long-term stable operation of an automatic machine will cause much concern in the area of assuring employment and keeping economical maintenance. The machine may come to be very expensive excessive equipment as a result. Therefore, we consider that present preparation plants need simple and easily maintainable measuring equipment for monitoring washing machine and be heightened awareness for coal quality control.

6.2 Treating of Waste Water and Circulating Usage of Washery Water

The cost of treating wastewater is a heavy burden in the running costs of preparation plants. To pursue treatment methods satisfying the environment standards at the lowest cost is a common issue in any country. In Vietnam, the combination of a settling pond which enables enough control of overflow water during rainy seasons and a minimum dehydrator are considered the best waste water treatment method when considering that the preparation plant has a large space of land in the surrounding area and personal expenses are low. In addition, it is important to use the purified discharged water from the controlled waste water treating facilities as plant water in circulation. Though Vietnam has comparatively rich water resources in general, the determination to use minimum necessary water at any time is important because more waste water treatment will be required as more water is supplied from outside. In that sense, the intention is to use water in circulation which will have the effect of emphasizing water saving.

6.3 Effective Utilization of washery Waste

The utilization of washery waste of coarse grain varies depending on marketability in the country and the characteristics of the washery waste. The application fields are aggregate for land creation and soil-improving materials as they are, and building materials, inner and outer wall materials, adsorbent and sub base materials for a road after heat processing. Here, what kind of rocks is mixed in the washery waste is important.

As an example, the case of the Taiheiyo Coal Mining Co. Ltd. in Japan is introduced here. In this mine, parting must be mined together with the coal seam to maintain a working height due to mechanized coal mining method. As a result, stones containing a mineral called “zeolite” are mixed in the raw coal. The stones are selected out by hand picking at preparation plant. They are sold as a soil improving material because they have the ability to adhere to fertilizers as they are, or they are sold as adhering material after thermal treatment. Also some companies sold shale which is included in large quantities in the washery waste, after baking as a firm building material. Because the cheap aggregate is difficult to get in Japan and heat processed shale has high commercial value at limited local area,

In addition, a study to utilize the wahery waste as light weight outer wall material was made as an example.

6.4 Noise and Dust Measures and Equipment

As for measures, water and mist sprinkling outdoors and noise-prevention equipment and dust collector indoors are necessary. It is especially important to adopt measures emphasizing each point of generation in a plant. As for dust measures, it is urgently necessary to make workers wear a dust mask consistently though the issue of installing equipment remains.

7. ENVIRONMENTAL REGULATION AND DEVELOPMENTS AFTER ENFORCEMENT 7.

ENVIRONMENTAL REGULATION AND DEVELOPMENTS AFTER ENFORCEMENTS IN JAPAN

Here the development and enforcement of waste water regulations for coal preparation plants in Japan is explained. At present, a coal preparation plant treating about 4 million tons per year discharges waste water to ordinary rivers with the S.S density below 150 ppm at any time. Actually, the density is half of that level, however, a long history transpired before they could do so.

At the time of the Water Preservation Law and Industrial Waste Water Regulation Law in 1958, regulation was rather loose and each coal preparation plant treated waste water by simple settling ponds. Then, in December 1970, the Water Pollution Control Law was established and enforcement began in June of the following year. Regulation under this law was very tight. Monitoring by a third party was determined and offenders were even ordered to stop operations. As a development process to implement the law, a five year temporary regulation was applied to coal mines. That was a 10,000 ppm regulation in 1971, 5,000 ppm regulation in 1973 and 150 ppm regulation in 1975. That period was a difficult trial period for engineers and managers of each preparation plant, however, the temporary regulation were very important and effective in making the preparation plants which must treat a lot of water, follow the law. The history of the technology development and the improvements are very interesting, however, they are omitted in this paper. At present a decant type centrifuge and a chamber type filter press are the major types of dewatering machine of coal preparation plants in Japan.

8. CONCLUSION

Coal, which is a precious energy resource in Northern Vietnam, will continue to have an important position in this economy. In order to utilize coal resources more widely and more effectively, it is important to wash coal before supplying it to customers, aiming to reduce the burden to the environment beforehand. As the mining sites shift to underground mining from open cut mining, an increase of ash in raw coal and comminuting raw coal are presumed and the necessity for preparation will increase. We look forward to further improvement of coal preparation technology in Vietnam.

9. ACKNOWLEDGEMENT

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